

# CONCEPT OF ECO-PLATFORM

Ryusuke Hosoda (Osaka Prefecture University),  
Tomohiro Nomura (Osaka City University),  
Katsuhito Yamaguchi (Osaka University) and  
Buichiro Murata (NPO: Osaka Bay Institute)

## SUMMARY

After the phrase "Think globally and act locally.", the authors propose a concept of "ECO-PLATFORM", setting their sight on the restoration of natural environments of the world. The Eco-Platform is a floating platform on which facilities are installed to dispose waste and sewage from land area, to reproduce heat/electric energy, to reproduce industrial resources/materials and to purify eutrophic sea water and contaminated sea bottom sediment. All the facilities and functions are integrated systematically to achieve no fossil energy introduction, cascade use of heat energy, efficient use of low-exergy heat energy and marine bio-technology, and to achieve the zero-emission principle. No new technologies are required to be developed for achieving the Eco-Platform. Some fundamental functions of the system have been studied for the realization of Eco-Platform.

It will give a desirable solution for environmental problems arose on the coastal area throughout the world.

## 1. INTRODUCTION

Arguments about the degradation of natural environments of the world have been repeated seriously for more than ten years. Problems have been reported with serious evidences, and discussed to grope suitable solutions and measures. We have recognized that almost all of environmental problems arose are results of long-period human activities on the land area, especially on the coastal area, such as over-population, civilization and industrialization. So that, we have to reconsider and change the human society in the 20th century supported by the social system of mass-production, mass-consumption and mass-abandonment.

According to a certain prediction, the world population will reach 8,000,000,000 in the first half of the 21st century, and more than 2/3 of the population will be concentrated in the coastal area. It may be easily imagined that the environmental problems will be much more serious in the coastal area throughout the world. We are not allowed to commit solution of environmental problems to the following generation. To find out solutions, ideas and measures have been developed and proposed so far, however, utilization of sophisticated technologies often requires the introduction of additional electric/heat energy that may cause the rise of entropy of the earth system. Introduction of new energy is not necessarily acceptable from the view point of long-term sustainability of the earth system.

The key word is "Sustainable development" for the achievement of final goal. To put it more definitely, we have to make efforts to ensure the human lives and activities, to maintain the ecosystem of fauna and flora, to use energy and resources efficiently and to reduce/recycle waste, etc. However, since we have been facing difficulties that there are no vacant land available in and around the highly populated urban area to build such annoying facilities, we have to find out a vacant plot where necessary conditions are satisfied.

The authors propose a concept of "ECO-PLATFORM", a system on which functions of sewage and waste disposal, resource/energy reproduction, eutrophic sea-water and contaminated sea-bottom sediment purification are highly integrated on a large scale floating platform. They are planning a system configuration under a support of NIRO (The New Industry Research Organization). This is a report on the concept of the "ECO-PLATFORM".

## **2. ENVIRONMENTAL PROBLEMS IN THE COASTAL AREA AT PRESENT AND IN FUTURE**

The human society has acquired the prosperity through the remarkable advances of science and technology and followed by the industrialization and economic developments. However, those developments have brought forth the excessive developments of the coastal land area and the neighbouring sea area through the urbanization and land reclamation of shallow water sea area.

As the results of those developments, overpopulation in the coastal urban and surrounding area and consequent life-style of mass-consumption and mass-dumping, the amounts of industrial waste and effluent and rubbish and sewage from residential area have exceeded the capacity of waste disposal and sewage process. Thus, everyone can imagine easily what the problems are/will be at present and in the future.

Problems relevant to the waste disposal and sewage process that have arisen/are arising/will arise on the coastal land area are :

- ① Big facilities which never exhaust toxic materials such as dioxin, SO<sub>x</sub>, NO<sub>x</sub>, etc. are required to be constructed to incinerate daily rubbish containing leavings, paper dusts, plastics, etc. from home. However, people never accept the construction of such annoying facilities in the neighbouring of their residential area. So that, there are no vacant plot available for the disposal site.
- ② Even if the current facilities are improved and used at the current site, the next problem to arise is how and where the incinerated dusts are disposed. The solution at present is dumping in mountains/forests or dumping to land reclamation sites in the shallow sea area. The latter is called PHOENIX project. Fig. 1 shows the ratio of land dumping and sea surface dumping in Japan. As shown in the figure, dumping sites on the land in Tokyo and Osaka Bay area are quite small.
- ③ Sewerage facilities are necessary to have big and high processing capacity because of the high concentration of population in the coastal land area. However, no sufficient plots for constructing facilities are available in and around the coastal land area.

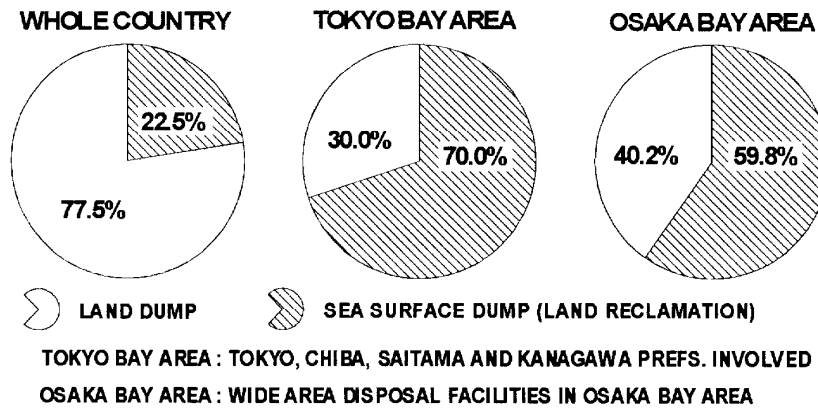


Fig. 1 Ratio of land dump and sea surface dump[ 1]

- ④ The concentration of nutrient salt in the drainage from the sewage process facilities is higher than 20 ppm now, sometimes higher than 100 ppm. So that, installation of additional electric power is required to remove nutrient salt from drainage by means of technical way.

Problems arose on the land area mentioned above are easily understood to lead the degradation of marine environments in the coastal sea area. They are:

- ⑤ Eutrophication of sea water that may be a cause of abnormal propagation of phytoplankton and resultant red-tides. Annual changes of concentration of nutrient salt DIN and T - P in sea-water at the inmost Osaka Bay is shown in Fig. 2 compared with that in the mouth of the bay. The situation of eutrophication is quite serious inmost area of Osaka Bay. In the same figure, annual changes of COD are also shown. From the figure, it is understood that the concentration of organic carbon in the seawater is in a serious condition too.

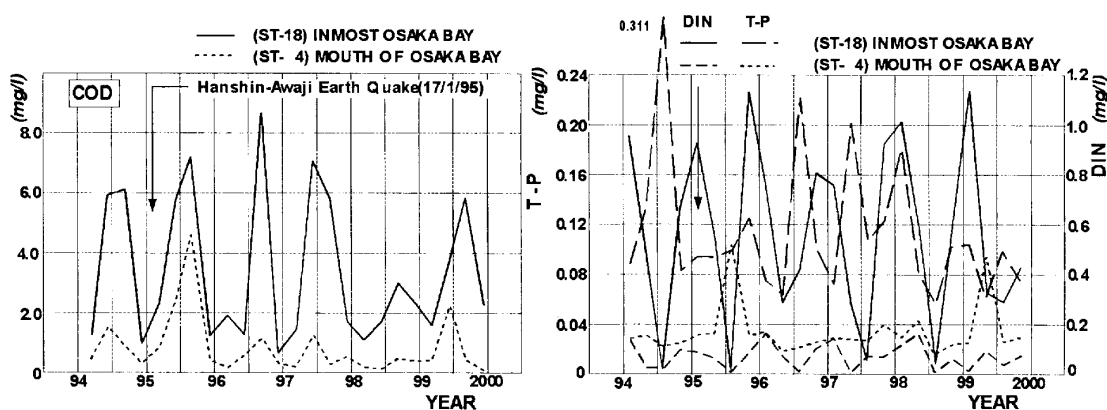


Fig. 2 Annual changes of concentration of COD, DIN and T-P at an inmost part and a near mouth of Osaka Bay[ 2]

- ⑥ Eutrophication of sea bottom sediment that may cause the bottom layer water anoxic and

change the ecosystem there. It may also dissolve the organic nutrient salt which may give rise to the abnormal propagation of another type of phytoplankton and resultant toxic red-tides. In Fig. 3, numbers of species and individuals of benthic animals inhabiting in bottom sediment are compared. At the inmost part of Osaka Bay, number of species is small though the number of individuals of *polychaeta* is big. It means that *polychaeta* has been a dominant species there. From the viewpoint of diversity of species, it is obvious the environmental situation at the inmost Osaka Bay is not acceptable.

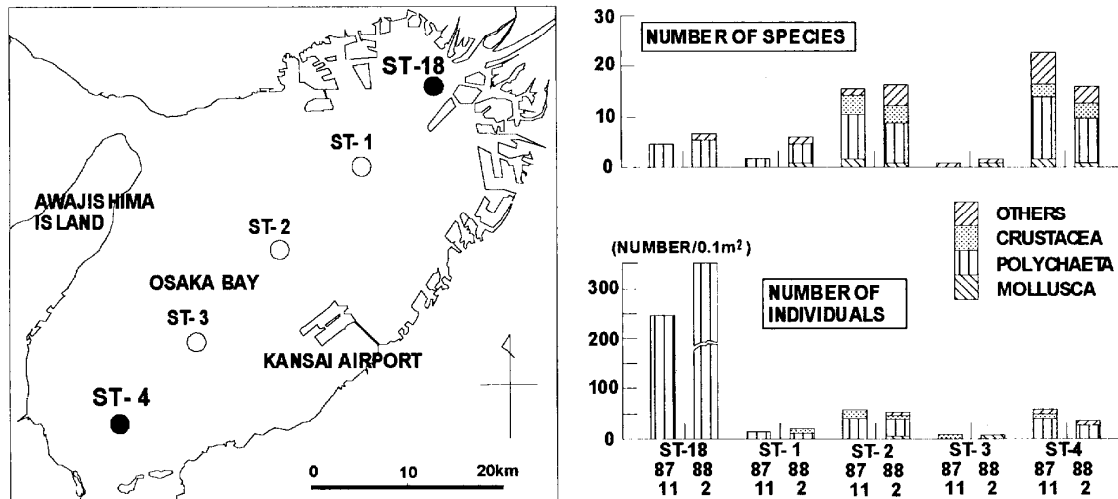


Fig. 3 Numbers of species and individuals of benthic animals in Osaka Bay [3]

The concept of Eco-Platform is thought out for finding out a possible solution in such situations of facing difficulties mentioned above. The Eco-Platform is a highly integrated facility complex on an offshore floating structure moored in a harbour anchorage. Facilities for waste disposal, sewage processing, heat-energy generation, power plant, energy and power storage and supporting systems and facilities are to be installed on the platform.

### 3. SOCIAL AND TECHNICAL REQUIREMENTS FOR THE ECO-PLATFORM

The Eco-Platform should be planned to meet requirements from various points of view. They are:

- ① It can offer effective measures for solving the environmental problems of waste disposal and sewage processing that have been arisen in and around the coastal city area as mentioned above.
- ② It can offer alternative spaces for the disposal facilities because there are no vacant plots available in and around the coastal city area where human lives and activities have been highly accumulated.
- ③ It can solve the marine environmental problems of the eutrophication and pollution of sea

water and bottom sediment and of the degraded ecosystem that have been in serious situations in the coastal sea area.

- ④ It can be operated without consuming no more fossil energy from the view points of avoiding green house gas exhaust and saving natural resources.
- ⑤ The heat energy reproduced in the process of incineration can be utilized in a cascade way such that generation of electric power from the high exergy heat energy, proliferation of seaweed and phytoplankton using the low-exergy heat energy, solar energy, etc.
- ⑥ It should not be left over as a permanent structure, because functions of the Eco-Platform are to be improved after the development of technology.
- ⑦ No pollutant loads such as toxic materials, contaminated sludge and eutrophic sewage should not be discharged to achieve the Zero-Emission principle.
- ⑧ It should finally accept any kind of waste and sewage which are always the results of human activities.
- ⑨ Applications of existing technologies are able to realized the Eco-Platform. Namely, it is to be the results of technology integration.
- ⑩ Low building costs is possible because expenses for the land are unnecessary, regulations such as the Building Standard Act and the Fire Services Act for example are not strictly applied.
- ⑪ Research, education and Evaluation functions are to be installed in the Eco-Platform system to promote next generation of environmental research works and business.
- ⑫ The Eco-Platform system is to be settled and operated at any coastal area where problems mentioned above arose/arise/will arise throughout the world.
- ⑬ It will provide a new desirable direction of ocean and marine science and technologies in the coming 21st century.

All of the requirements assigned to the Eco-Platform are not necessary to be achieved in the same time. It is necessary to achieve the technology integration through the developments of individual assignment and corresponding technologies.

#### **4. CONCEPT OF ECO-PLATFORM**

Since the Eco-Platform is a sophisticated facility complex, it is necessary to discuss from various points of view. So that, we will discuss about the feasibility of offshore system for the industrial waste disposal and offshore sewerage system with incidental functions. And then, we will mention about the configuration of the Eco-Platform as an integrated system.

##### **4.1 Offshore industrial waste disposal system**

One of possible configuration of Eco-Platform can be drawn as shown in Fig. 4 after the discussions above. The main purpose of the system shown is the disposal of industrial waste including effluents from factories and discarded building materials from construction/ recon-

struction sites. Electric power and heat energy generated by the incineration of waste are to be used for recycling and reproduction of materials and resources. Another point of the system is the shortening of land carriage of waste. It is easily achieved using waterways spread over a coastal urban area with RO/RO waste barge and/or waste barge systems shown in the figure. And, if the system had a stock yard in the platform, no stock yards are necessary to be arranged onshore. Then, accessibility to the shoreline will be improved very much.

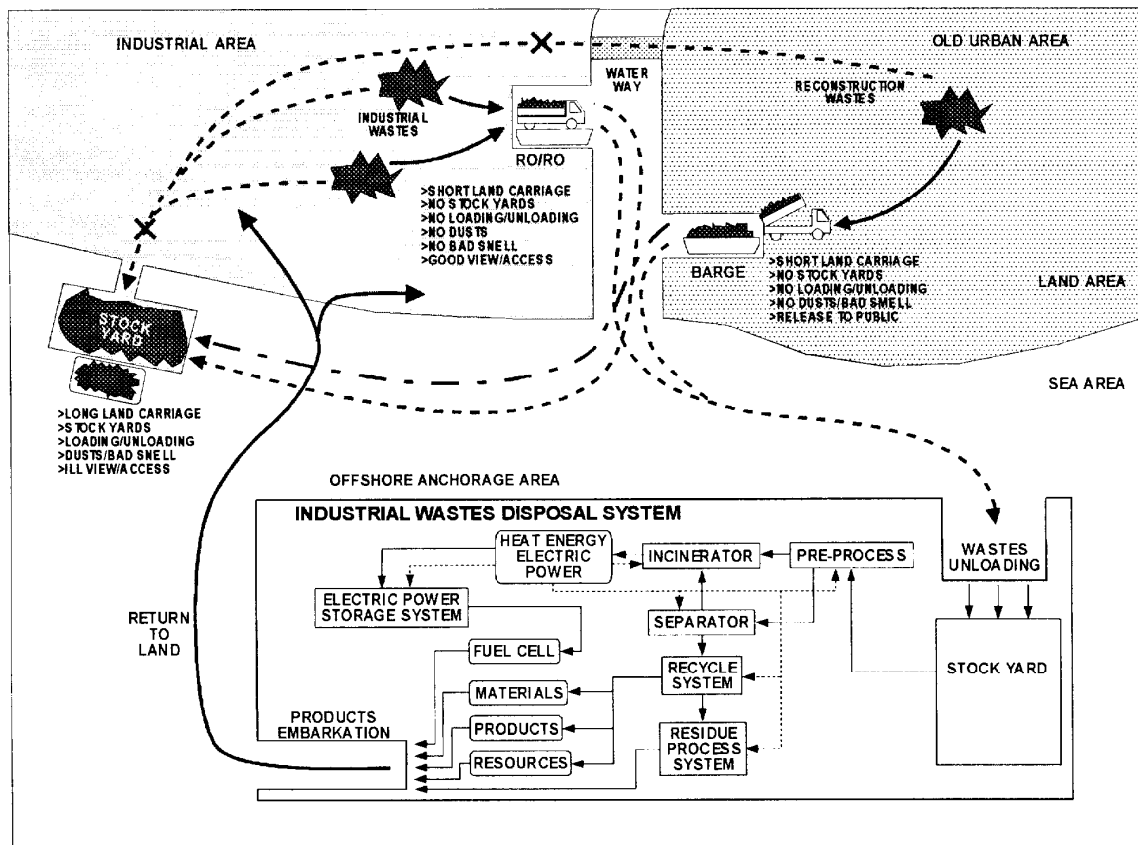


Fig. 4 Eco-Platform for waste disposal system

#### 4.2 Offshore sewage process system

Serious problems that coastal area has been facing are the pollution and eutrophication of seawater as mentioned above. It has been understood that processed drainage from sewerage system is the main cause of the eutrophication. To solve the problem of eutrophication, the acts we have to do are improvement of sewerage system and change of our lifestyle not to discharge contaminated sewage from home, however, it is very difficult because people do not accept to lower their living standard. So that, it is necessary to develop an advanced system for waste disposal and sewerage from which discharges of no toxic matter, no green house gases and no drainage of high nutrient concentration are guaranteed.

An offshore waste disposal and sewerage system is proposed here. The system is constructed

on a large floating platform where integration of functions such as (1) Waste disposal, (2) Purification of sewage and eutrophic seawater, (3) Energy generation, utilization and storage and (4) Resource reproduction are achieved. The flow for achieving the four main functions of the system is shown in Fig. 5. The distinctive features to be installed on the system are:

- (1) Supply of heat energy by incinerating waste and Refuse Derived Fuel from the land area

No fossil energy is able to be used on the Eco-Platform. Heat energy from incineration plant is to be used to keep the all systems in full play with the additional use of natural energy.

- (2) Cascade utilization of heat energy

High temperature heat energy is generated from the incineration facility. The higher exergy energy is used for generating electric power first, and then high temperature steam supply, etc. in a cascade way. However, the low-exergy heat energy has been let flow away, but has not been fully utilized because of low efficiency. It is to be used for the algae-culture system and methane fermentation system on the Eco-Platform, because marine organisms as well as bacteria for the fermentation have strong potential in the atmosphere of rather lower temperature than 100 °C. Thus, the cascade utilization of heat energy is achieved.

- (3) Application of algae-culture system for assimilating nutrient salt

Using the low-exergy residual heat energy, natural energy, artificial lighting and sunlight, some kind of laver, *U. lactuca*, or some kind of phytoplankton are proliferated under the

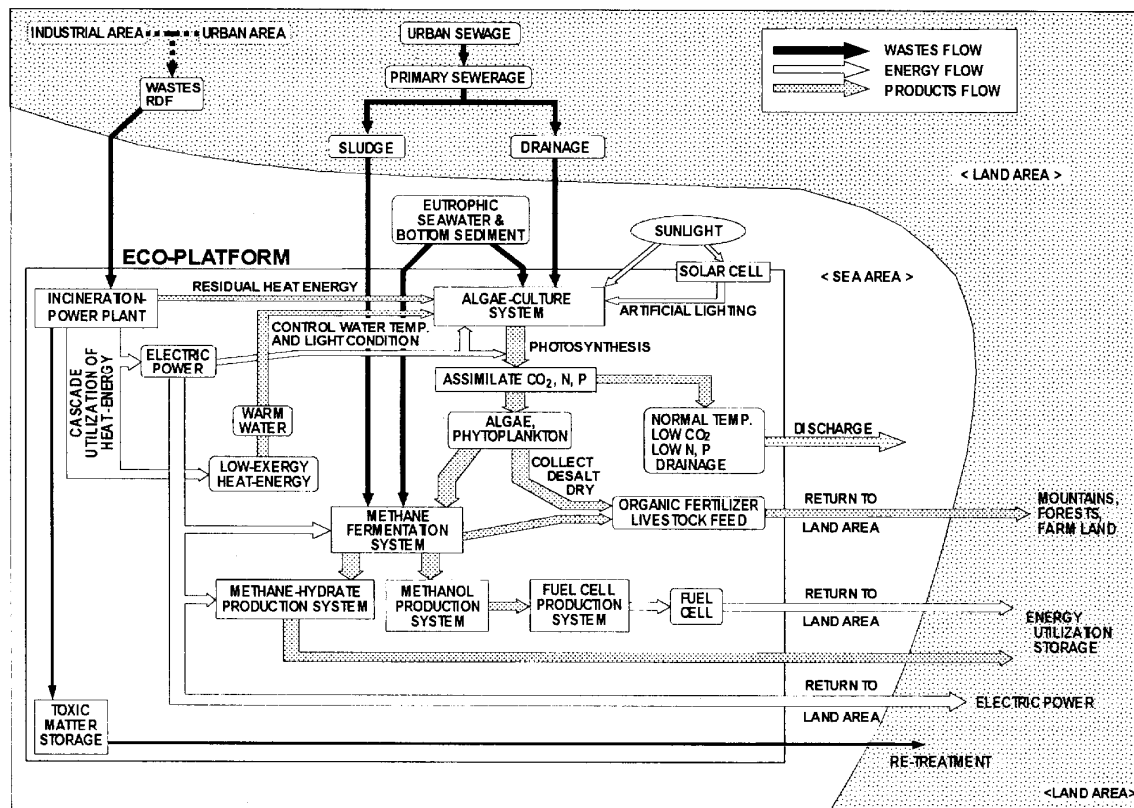


Fig. 5 Integrated offshore system for advanced waste disposal, sewerage and reproduction of energy/resource

optimally controlled water temperature, light condition. etc. to assimilate the nutrient salt concentrated in the drainage from onshore sewerage system and to reproduce organic fertilizer, livestock feed and to reproduce materials and energy.

(4) Purification of seawater and sea bottom sediment

Eutrophic seawater is treated in the same system of laver / phytoplankton proliferation. After the nutrient salt concentration is reduced lower than a prescribed upper limit, say 0.1 ppm DIN for example, the drainage is to be discharged into the eutrophic sea area. Since the drainage is rich in DO provided by the photosynthesis, it is to promote the decomposition of organic carbon and nitrous compounds by aerobic bacteria in the bottom layer seawater and sea bottom sediment

(5) Application of methane fermentation for regenerating secondary storageable energy

The products from algae/phytoplankton-culture system and the organic sludge from onshore sewerage facilities are provided to the methane fermentation system to produce methane gasses.

### 4.3 Concept of Eco-Platform

The principal concept of the Eco-Platform is solution to the environmental problems and related problems now facing and will face in the coastal area. Therefore, we have to integrate all the functions and facilities on a large floating platform. Fig. 6 is the schematic representation of the Eco-Platform. As shown in the figure, the Eco-Platform is understood a sophisticated facility complex on which functions are to be installed and integrated systematically for waste disposal,

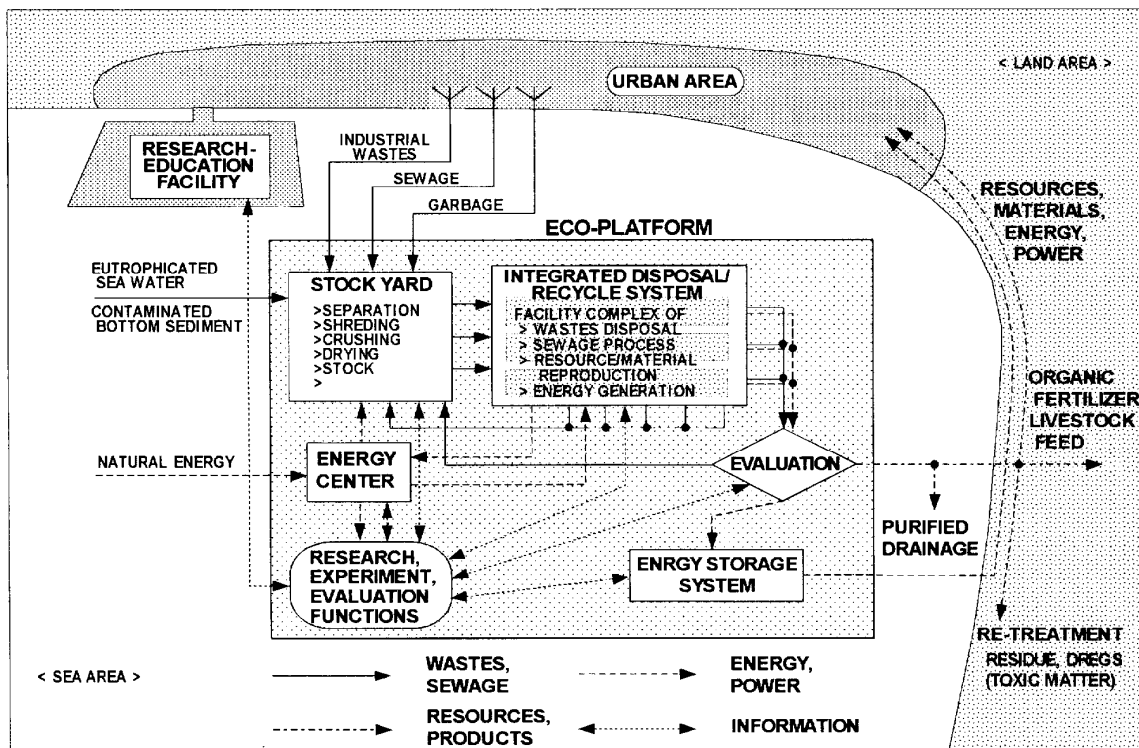


Fig. 6 Schematic representation of Eco-Platform



sewerage, energy generation and storage and recycle/reproduction of materials and resources. Each system unified in the Eco-Platform can be realized and operated separately on an individual platform as mentioned above, however, one of the most important points of the Eco-Platform is achievement of high-efficiency integration of functions.

The receptions of waste, sewage and rubbish from the land area by barges or pipeline systems are unified as a Stock Yard, where necessary functions are installed. The energy generation and supply are controlled at the Energy Centre as shown in the figure. The principal functions are unified in the Integrated Disposal/Recycle system. Products or residue matters are treated by means of suitable ways after examined whether they are innocuous or not, and after evaluated whether drainage are oligotrophic or not. Research, education functions are equipped to carry out further study about the technology improvement and to educate people for promoting environmental consciousness.

## 5. PREPARATORY STUDIES ON THE ECO-PLATFORM

Several preparatory feasibility studies have been carried out to convince of functions to be applied to the Eco-Platform.

### 5.1 Feasibility of offshore incineration platform [4]

Technologies for building, mooring and safety of large floating structures had been established by research group of "Mega Float". So that, the financial possibility of constructing incineration facility on a large floating platform was studied. Table 1 is the specification of incinerating facility.

Table 1 Specification of offshore incineration platform

Incineration capacity	460 ton/day (230 ton/day x 2)
Total floor area	6,000 m <sup>2</sup> including incineration furnace, rubbish pit, incidental and loading facilities.
Deck area	20,000 m <sup>2</sup> (2 ha)
Construction site	Offshore anchorage area
Sea state condition	Tidal current: 0.3 m/sec, Wave height: 2.5 - 3 m, Wave length: 50 - 60 m (Hurricane)
Weight	
Incineration facility	9,000 ton (4,500 ton x 2)
Incidental facilities	4,500 ton
Waste	2,000 ton (max.)
Others	2,000 ton

The results of studies about main hull weight, building cost, building cost of main hull and building cost of mooring facility are shown in Figs. 7, 8, 9 and 10[5]. In the figure, FRW means a Floating Run Way and ★ indicates the estimation for the incineration platform.

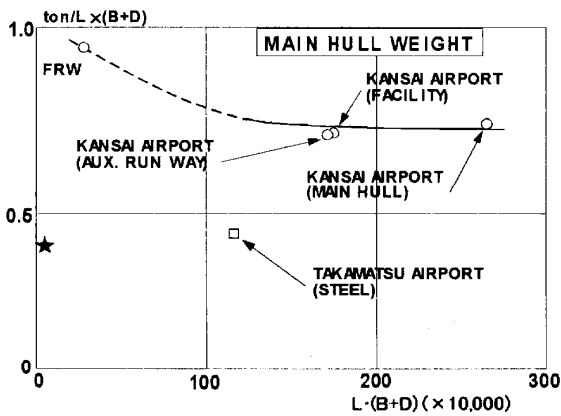


Fig. 7 Estimation of main hull weight

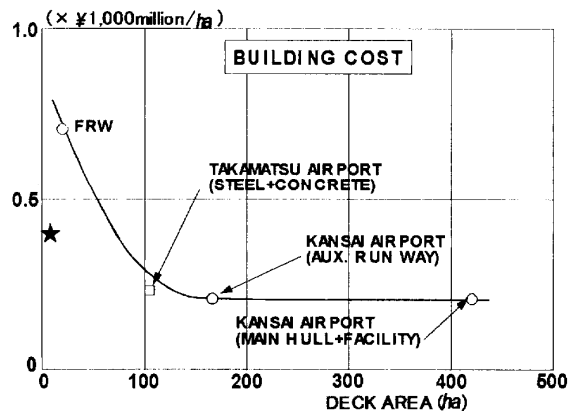


Fig. 8 Estimation of building cost

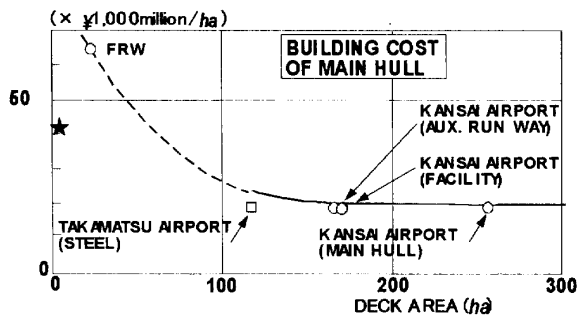


Fig. 9 Estimation of building cost of main hull

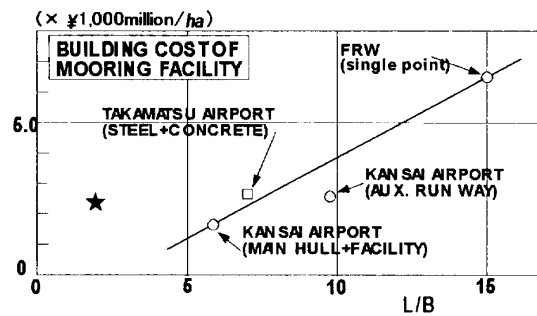


Fig. 10 Estimation of building cost of mooring facility

Using these estimated results, the outline feature of the floating incineration facility is obtained as shown in Table 2. As shown in Table 2, the floating incineration platform is feasible since the expenses for acquisition of land is very high.

## 5.2 Feasibility of algae-culture system for assimilating nutrient salt

Using a marine ecosystem model shown in Fig. 11, numerical simulations were carried out to investigate the feasibility of assimilating nutrient in the phytoplankton-culture system. Since there are few published data available for the simulation, rate of photosynthesis, assimilation rate of nutrient and other necessary information were estimated. Though further

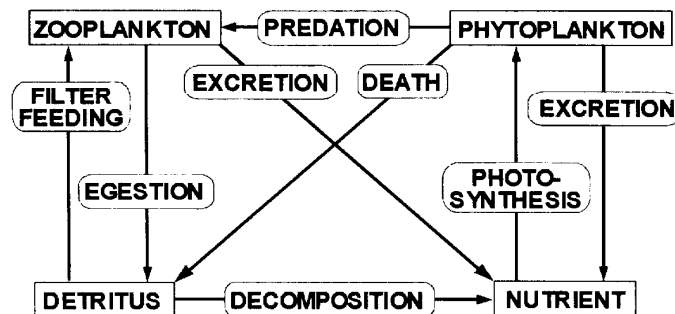


Fig. 11 ecosystem model for simulation study

Table 2 Construction costs for the floating incineration facility

DISPOSAL FACILITY SPECIFICATION, COSTS		ON SHORE SYSTEM (Existing)	ON SHORE SYSTEM (Planned)	OFF SHORE SYSTEM (Planned)
AREA OF SITE	(m <sup>2</sup> )	35,000	30,000	20,000
TOTAL FLOOR AREA	(m <sup>2</sup> )	23,000	24,000	24,000
CONSTRUCTION AREA	(m <sup>2</sup> )	8,000	8,000	8,000
OFFICIAL CAPACITY	(ton/day)	460	460	460
C O S T S	COSTS FOR SITE	6,700	6,000	8,000
	FACILITY			
	CONSTRUCTION COSTS	19,000	20,240	16,100
	COST FOR MOORING	0	0	500
	OPERATION COSTS	200	200	500
	BUILDING COSTS FOR			
	WASTE BARGE	0	0	1,000
	OTHERS	800	800	1,000
TOTAL COSTS		26,700	27,240	27,100

- N.B.) 1. Unit of construction costs : ¥1,000,000  
2. Unit of cost for Land acquisition : ¥200,000  
3. Building costs for a floating platform : ¥4,000,000,000/ha  
4. Construction costs for facilities (onshore) : ¥44,000,000/ton  
(Estimated from past records. Incidental facilities and building included)  
5. Construction costs for facilities (offshore) : ¥35,000,000/ton  
(Incidental facilities and building included)

investigation is necessary, a certain solution about the possibility was obtained. If the nutrient salt concentration of input drainage is 2 ppm, it will take about 100 hour to reduce the concentration to 0.1 ppm as shown in Fig. 12, for example.

On the other hand, if we use a kind of laver *U. lactuca*, the time for the assimilation of DIN reduces less than half. We have to continue the preparatory investigation furthermore to ensure the usefulness of algae-culture system.

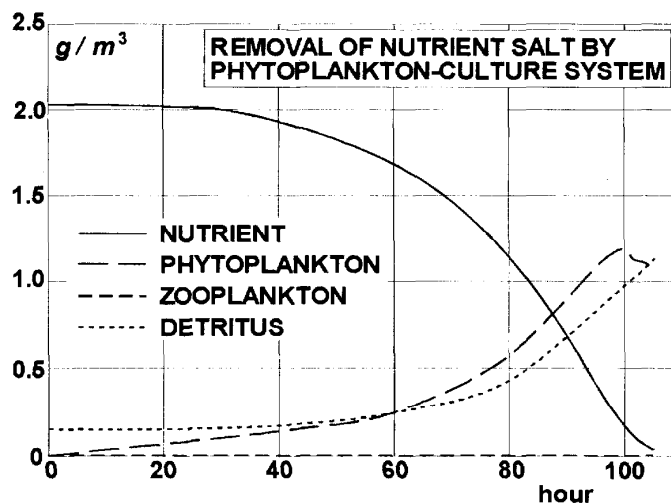


Fig. 12 Removal of nutrient salt by phytoplankton-culture system

## **6. FUTURE ASPECTS OF ECO-PLATFORM**

In order to realize the Eco-Platform, some fundamental and practical research works have to be carried out. They are (1) Construction and operation of systems on a floating structure, (2) More detailed basic studies on algae-culture system, (3) Cascade energy utilization and natural energy utilization, (4) Waste and sewage transportation, (5) Total system integration and so on. Also, since the social, economic, technical and financial conditions are not the same throughout the country, or the world, combination of functions and corresponding facilities are to be taken into consideration. In such a case, waste disposal system shown in Fig. 4 and sewerage system in Fig. 5 are constructed and operated as an individual system.

In the beginning of the 21st century, development of social, economic, cultural and industrial infrastructure in the coastal area as well as the re-development of old industrial and urban area will start. Since the infrastructural developments have been proceeded from viewpoints of the land in the 20th century and many problems including local and global environments have been arising as the results. In the 21st century, we have to change the strategy in developing the coastal area. Namely, viewpoints from the sea will become much more important for the sustainable development of people and surrounding ecosystem.

The Eco-Platform project will play an very important role as a core of development.

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